

# A CONTRIBUTION TO THE GENESIS OF SPEECH MOVEMENTS

A DISSERTATION

Submitted in Partial Fulfillment of the Requirements  
for the Degree of Doctor of Philosophy  
in the  
UNIVERSITY OF MICHIGAN

HIDE HELEN SHOHARA

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*Reprinted from* THE QUARTERLY JOURNAL OF SPEECH (June, 1935),  
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## A CONTRIBUTION TO THE GENESIS OF SPEECH MOVEMENTS<sup>1</sup>

THIS dissertation is a contribution to the establishment of the thesis, that the speech movements of the oral and pharyngeal structures are modifications of the movements of sucking, swallowing and chewing.

For many centuries after Aristotle (384–322 B.C.) language study in Europe chiefly consisted in the classification of the phenomena of language on formal logical bases and in conjectures concerning the nature and origin of language. The Revival of Learning brought only minor changes in these methods. Even the development of the natural sciences had for some hundred years only a slight affect upon the studies of the philologists, who regarding language as mainly a product of the mind, neglected the physical aspects of language study. It was only natural therefore that scholars interested in the problems of mind should be led to take an interest in the phenomena of language. Outstanding contributors to psychological theory since the Renaissance are DesCartes (1596–1650), Hobbes (1588–1679), Spinoza (1632–1677), Locke (1632–1704), Leibnitz (1646–1716), Berkeley (1684–1753), Hartley (1705–1757), Hume (1711–1776), Kant (1724–1804), Herder (1744–1803), Herbart (1776–1841), Fechner (1801–1887). The speculative character of their work is reflected in the syntactical lucubrations of such linguists as Hartung, Michelson, Rimpl, Steinthal and others. Meanwhile during the 18th and 19th centuries the newly-developing science of physiology was gradually taking form. Physiologists were at first interested in speech merely in its abnormal aspects (stammering, stuttering, etc.), but later on began to deal with the normal activities of the speech organs. For example Johannes Müller, *Elemente der Physiologie* (1833) devotes book IV to “Motion, Voice and Speech,” and includes an account of the physics of sound. Important additions to “Phonetics” which was then rapidly assuming an experimental form (Kempelen, Techmer, Czermak, Helmholtz, Rousselot, Scripture, etc.) were made by the physiologists Weber (Weber’s law), Fechner, von Humboldt, Hering and especially Wundt (*Völkerpsychologie*, Vol. I).

<sup>1</sup> A résumé of the dissertation completed under the direction of Professors C. L. Meader and J. H. Muyskens and submitted by the author to the faculty of the University of Michigan in June, 1932, as a partial fulfillment of the requirements for the degree of Doctor of Philosophy.

It was reserved, however, for the enormous advances in physics to infuse new fundamental ideas into the science of language. The work of Michelson (measurements of the velocity of light, 1885), Roentgen (discovery of X-ray, 1895) and many others, through the electrical theory of matter and chemical action, served as a stimulus to other studies and to the eventual union of the sciences of physics, chemistry and physiology into one comprehensive science (including of course biology). The highly refined apparatus of physiologists are at present employed in breaking down the barriers that for centuries have isolated the humanistic sciences from the natural sciences and mathematics. The application of biological methods and data to the interpretation of language may now be regarded as fully justified.

The specific patterns of muscular movements occurring in sucking, swallowing and chewing are described in this dissertation on the basis of personal dissections and pertinent investigations written on the subject by anatomists, physiologists and pathologists. The evidence concerning the articulatory movements of speech was secured from direct observation, from laryngoscopic inspection, from X-ray photographs and from kymograph records.

The fundamental principle of this dissertation is that *all structures arise from previously existing structures, and that all processes arise from previously existing processes*. This is a fundamental law of evolution accepted by all scientists. The structures directly involved in speech are identical with those employed in the food-getting processes. The muscles of the larynx, lips, palate and jaws have developed embryologically from the cephalic end of the primitive gut. All the ontogenetic and phylogenetic evidence available indicates that the oral and pharyngeal structures used in speech movements were developed primarily in connection with the food-getting movements. Oral communication is a function of the alimentary organs. It developed secondarily, albeit over a very long period, co-eval with the development of the alimentary functions.<sup>2</sup> It is a by-product of alimentation made possible largely by the fact that certain alimentary organs in the performance of their specific functions agitate the air and thus produce sensation of sound in such animals as have adequate auditory apparatus. The development of the nose and hence breathing through the nose are late refinements. Breathing of the vertebrate animals occurred primitively through

<sup>2</sup> From the amphibia on.



the mouth. Minkowski<sup>3</sup> notes the retention of this type of breathing in prematurely born fetus of 22 to 28 weeks.

The course of development follows the line of continually greater increase in structural complexity of the organs, attended by increasing flexibility and greater complexity of movement. In consequence of this evolution we find that even in the lowest mammals, the lips, cheeks, tongue, jaws, larynx and pharynx have reached such a specificity of structure and function that they are already in a condition to execute extensive and varied movements. In the articulatory movements of human speech functional complexity and specificity attained their highest degree of intricacy and exactness.

It should be borne in mind that both the food-getting movements and the speech movements serve the same general purpose, namely, the advancement of the welfare of the organism through its integration with its environment, the former acting directly and the latter indirectly (that is, through other organisms), but both as tools in the strict sense of the word. Moreover aside from the speech movements, no movements of the oral and pharyngeal structures are known to exist which are not manifestly concerned directly or indirectly with providing food (including gaseous food, i.e., oxygen).

The mere fact that the speech movements are of later origin than the direct food-getting movements suggests that the former are modifications of the latter.

Aside from these general considerations, there is available much evidence of a more specific character in support of this thesis. This is in part as follows:

1. The alimentary processes of the cephalic portion of the alimentary canal are largely automatic, but are subject to considerable voluntary control. Speech movements, like all others, become automatic when frequently repeated. In fact the automatic movements of speech are more "accurate" than voluntary controlled pronunciations, as is abundantly testified by kymograph records.

2. The two processes resemble each other closely in detail. If we consider the individual consonant contacts in isolation, we find that the specific action of each muscle or muscle group in articulation bears a close resemblance to, or even identity with, specific component movements of swallowing, sucking and chewing. Although the application of analysis to an organic series of contractions is arbitrary and artificial, since it disregards the integrated character of

<sup>3</sup> Schweitzerische Medicinische Wochenschrift. 1922 (No. 30), p. 754.

the total series thus analyzed, yet it has its value, since the exact character of the individual components of the series can be observed in both cases *in the form in which they occur in the series*, and their differences recorded.

a. The act of occlusion of the lips, involving in some instances their compression against the teeth, is also that by which the lips aid those acts of grasping food, and of biting in which the incisors are involved. These are also the initial movements of [p, b, m]. Since the position of the lips in normal breathing is that of contact (occlusion), it follows that the break of the bilabial consonants is merely the normal initiation of the act of grasping food.<sup>4</sup>

b. In the production of such a succession of movements as [pf] as in *hopeful*, there is, in addition to the movements noted above, a tension of the buccinator muscles compressing the cheeks against the premolars as in chewing. This, however, is not essential to the [f], but is an accessory, or perhaps even adventitious, movement attending it, being really an anticipated movement of the following vowel [u].

c. In the production of the [pθ, bð] (as in *upthrow, rub that*) the make (closure movement) of the [p] or [b] is followed by a tongue-tip movement which closely resembles the tongue-tip and tongue-blade movements of the suckling baby. The movements following the make of [p] or [b] in the combinations [pt, bd, bn] are food transportation movements along the palatal rugae.

d. In the production of fricatives and affricates [ps, bz, ptʃ, bdʒ] (as in *campstool, mobzone, stepchild, rob George*) the lip action above described is attended by a slight rise and tension of the blade of the tongue of the same type as that employed in transporting the bolus of food toward the *isthmus faucium* preparatory to swallowing.

e. The movement of the lips (protruding and puckering) made at the same time is particularly noticeable in [ptʃ, bdʒ, pw] (as in *stepchild, rob George, Lapwing*) and is characteristic of sucking and osculation.

f. The movement [pj] (as in *leap year*) closely resembles the act which would carry the bolus of food still farther back toward the fauces.

g. Another close parallelism between chewing and swallowing movements and speech movements is found in [l, r], which may be unilateral, either right or left. Similarly we find right- and left-sided

<sup>4</sup> Compare, however, footnote 3, p. 5.



swallowing. This is shown by some 200 palatogram records of swallowing, chewing, and articulation of [l] and [r] made in the Laboratory of Phonetics of University of Michigan.

h. When pronouncing [k] and [g], particularly after the vowels [a, o, u], the tongue makes a contact with the back palate such as is made in swallowing. This movement, of course, is unaccompanied by the constriction of the anterior pillars, since the bolus is absent, being replaced by the outflowing stream of air. The movements of [k, g] represent therefore an abbreviation of a stage of the swallowing process.

Taken, then, in succession, this series of movements from lips to the root of the tongue constitutes a close parallel to the normal primitive processes of food-taking, namely, sucking and swallowing. The jaw movements which are of later phylogenetic origin, play only an accessory part in speech.

3. Overlapping. By *overlapping* is meant the partly or completely simultaneous performance of contractions (whether of the fixators, adjuncts or specific motors) that are popularly regarded as constituting successive "sounds" or "letters." Structurally we may distinguish the following forms of overlapping:

- (1) of different portions of the same organ;
- (2) of different organs adjacent to each others;
- (3) of different organs remote from each other.

Both the sucking and swallowing movements and speech movements are marked by overlapping of all three types. For example, the contraction of the lips which sweeps food into the mouth is still maintained while the processes of chewing and swallowing are going on. Indeed this is doubtless the physiological basis of the law of etiquette that one should keep the mouth closed while chewing (and swallowing). A further reason for the continued tonic contraction of the lips is that breathing continues during chewing, and if the lips are open, bits of food might during inspiration be drawn in through the pharynx into the larynx. There we have a movement, or at least a tonic condition, of contraction maintained for a time after the end to be accomplished has been effected, and while a different function is occurring. If we examine carefully such a succession of movements we find a further striking resemblance between articulatory and alimentary movements. It is of course patent that in the productions of the voiced consonants and the vowels the intrinsic muscles of the larynx are active simultaneously with those of

the tongue, jaws and lips, not to mention such muscular activity as might occur in the breathing apparatus. Many such instances occur, since both speech and the alimentary processes are the coördinated activity of several different organs, some of them acting simultaneously. In the articulation of speech movements a similar overlapping continually occurs, although the wide-spread use of the alphabet and the emphasis laid on correct spelling often prevent the layman from observing it. But for this overlapping, speech movements would be much slower than they are, and their variations greatly reduced in extent. This "speeding up" (economy of time) of movements is clearly shown in kymograph records in which is observed that the length of time occupied by an entire series of muscular contractions frequently exceeds by only a small amount the shortest time required for one component movement of average normal speed.<sup>5</sup>

4. Continuousness of action. Although the modern written and printed page presents words to the eye in the form of separate detached units, this is not the case with the spoken sentence. In the spoken sentence the movement does not cease ordinarily from the beginning until the end of the sentence. So in swallowing the process is continuous.

5. Energy of contraction. It requires no experimental evidence to demonstrate that the muscular contractions of the alimentary processes are considerably more energetic than those of articulate speech. This fact is due to the presence of resistant food in the former case, and to the consequent necessity of chewing, triturating, propelling and swallowing it. In these processes there is more work to do, whereas in speech there is either only the tissue alone to set in motion or a very slight positive air pressure to be overcome. This difference in work to be done makes the greater rapidity of contraction possible in articulate speech.

Accent in speech consists in variations in loudness, in pitch and (perhaps we may add) duration. All three forms of variation are produced by variation in energy of muscular contraction. An even rhythmicity (that is, regularity in the succession of energy outputs and periodicity in the wave of contraction) is characteristic of the

<sup>5</sup> This overlapping is a general characteristic of the neuromuscular processes. Professor Meader has an extensive collection of instances occurring during the process of writing and other activities. Professors Meader and Shepard noted and studied this phenomenon in 1912.

stages of the swallowing processes. However, variation in energy of contraction does occur here as a result of the resistance to progress offered by the condition of the bolus. Thus accent in language has its archetype in swallowing. Here the difference between articulation and swallowing lies chiefly in the difference in stimulus.

6. The great majority of the consonants in the Indo-European languages are made with the lips and with the tip and the anterior part of the dorsum of the tongue. If a page of printed matter be taken at random and a count be made of the consonants actually used (counting each occurrence of each consonant), the ratio of tongue-tip movements to tongue-back movements will be greatly increased. Over 80 per cent of the total number of consonants pronounced will be found to be made by the tip of the tongue and the lips. The same proportionate representation is found in ancient Sanscrit according to the statistics of the occurrence of the sounds reported in the *Journal of American Oriental Society*, Vol. 10, p. cl-clii. This also indicates that the bulk of the consonants are to be regarded as developed from the movements of the tongue in sucking, chewing and trituration. The tip of the tongue, which is more exclusively muscular than the base, is developed by invasion of myomeric (?) muscles in connection with the triturating activities, and so has acquired a much greater mobility than the base. Incidentally, of course, the tip of the tongue is exposed to a much wider range of variation in stimuli from environment than is the back of the tongue, and this fact contributes to the development of a high specificity of its neuromuscular structures and functions.

7. When we turn to the vowels, we find a diametrically different situation. Vowels are formed not by the tip, but mainly by the contraction of muscle fibers in the posterior portion of the dorsum and root of the tongue that rise up in the form of the crest or transverse ridge as in swallowing, the tip playing only an accessory part. In the vowels, as in swallowing, the posterior half of each lateral region of the tongue is slightly elevated above the line of the center as a natural result of the contraction of the styloglossus. This distribution of the extreme upward movements of the tongue in pronouncing the vowels again emphasizes the close resemblances between the vowel movements and swallowing. As G. Oscar Russell<sup>6</sup> pointed out in his repudiation of the traditional theories concerning the vowel triangle, the old picture of the vowel triangle inculcates a decidedly erroneous

<sup>6</sup> Russell, *Speech and Voice*, 1931, p. 79.



idea of the character of the vowel movements. I have made separate composite pictures of Russell's X-ray figures and those of Gutzmann<sup>7</sup> by superimposing the figures and drawing a curving line along the median crest of the tongue as it appears in each figure, and have secured composite figures such that all the crests will fall (with the exception of some of those representing [a] within a curved oval lying just below the back half of the hard palate and the palatine velum. We should thus speak of a vowel oval rather than of a vowel triangle. Even such a corrected picture is only two-dimensional, whereas speech movements, far from being two-dimensional, are not even merely three-dimensional, involving as they do volume, but are four, five and even multi-dimensional, involving time (movement), intensity and other factors.

Along with these resemblances, there are certain differences. In the act of sucking and swallowing the successive muscular contractions follow the peristaltic order of succession, i.e. they proceed in a caudad direction. In speech, however, the successive movements in most instances alternate between the cephalad and caudad directions. On the basis of probability the cephalad and caudad shifts should occur in about equal numbers, and in this fact consists the most conspicuous difference between alimentary and speech movements. Take any normal sentence, e.g. "This is the forest primeval."

ð → ɪ ← s → ɪ ← z ← ð → ə ← f → ʊ ← r → ɪ ← s = t ← p → r → ɑ ← ɪ ← m → i ← v → l<sup>8</sup>

In the 20 shifts from region to region of contraction there are 15 shifts of direction. In only 3 instances do two successive shifts follow the same direction, one peristaltic, the other 2 antiperistaltic; 9 movements are peristaltic in direction, 10 antiperistaltic. At one point [st] there is no change.

"But as for me, give me liberty or give me death" shows 13 cases of peristaltic direction, 17 cases of antiperistaltic direction, including 2 cases of 3 successive antiperistaltic shifts, 2 cases of 2 successive antiperistaltic shifts, and 2 cases of 2 successive peristaltic shifts.

b → ʌ ← t → æ ← z ← f → ʊ ← r ← m → i → g ← ɪ ← v ← m → i ← l → ɪ ← b → r ← t → ɪ →

ʊ ← r → g ← ɪ ← v ← m → i ← d → ɛ ← θ

<sup>7</sup> Gutzmann, Fortschritte auf dem Gebiete der Röntgenstrahlen, 41 Band, 1930, p. 392.

<sup>8</sup> The arrows show the direction of the shifts.

There is no reason to suppose that the above two sentences are exceptional. If we disregard the vowels and take the direction only from consonant to consonant the situation is not materially changed.

It is clear that *omission* of movements and the *reversal* of *direction* are the two most striking differences between the articulatory processes and those of sucking, swallowing and chewing, and that these differences lie not so much in the character of the individual movements as in their relationships. This alternation of relationships, however, is a fundamental characteristic of all natural processes.

While the analysis of the contractile activities of the oropharyngeal musculature thus reveals the genesis of the speech movements it should be added that an extensive investigation of the subject would involve a further study of the neurological aspects of the problem, and take us into the field of central and sympathetic nervous activity, glandular secretion and the influence of other systems of muscular processes over the speech movements. There can be no doubt that all such evidence would corroborate the thesis here defended.







